Optics Development at the Brera Astronomical Observatory (OAB) for Constellation X

Part B

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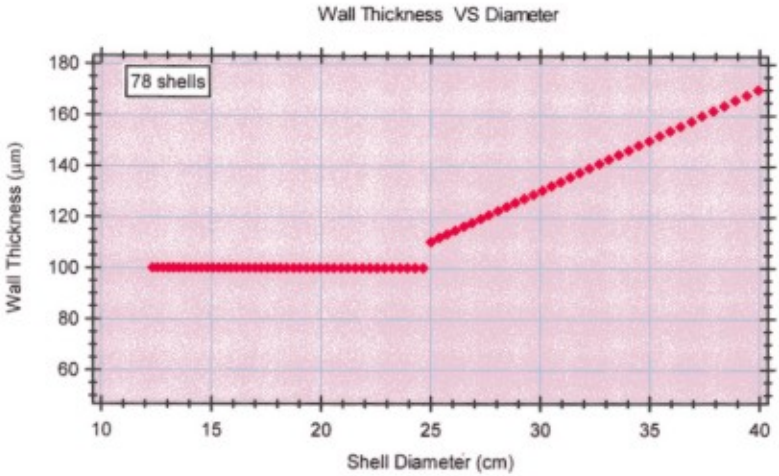
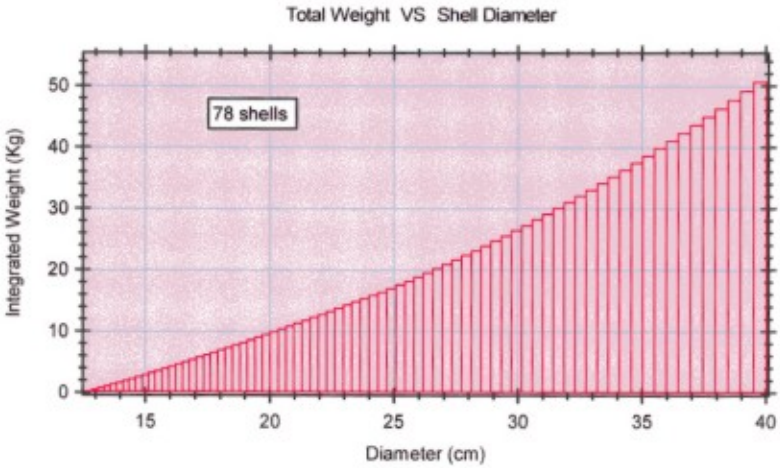
3 modules/satellite configuration

Total Weight/Satellite = 200 Kg
(including structure, 30 % of mirr. weight)



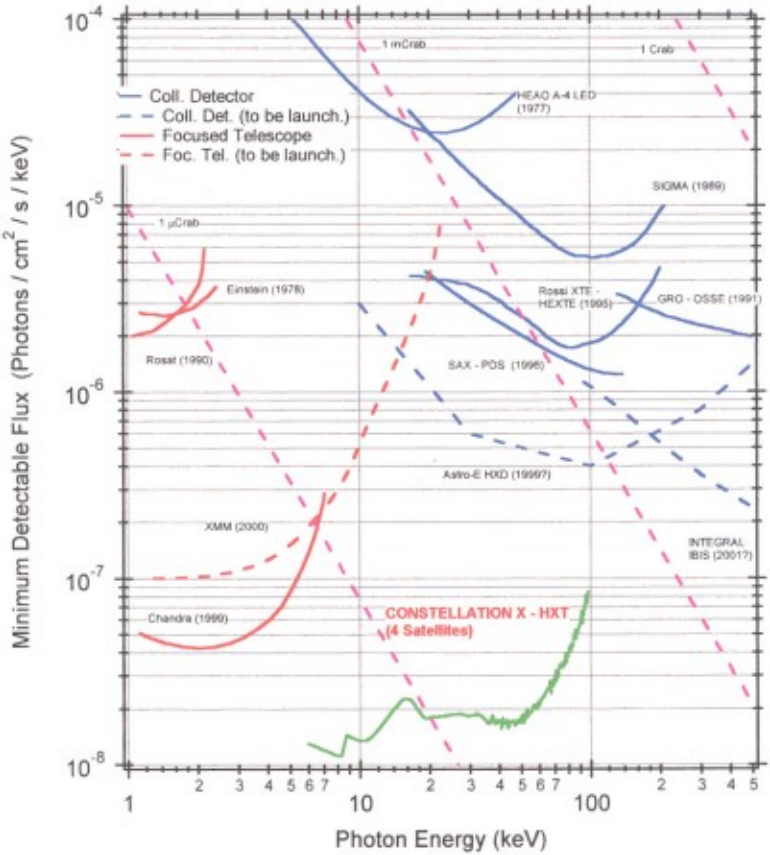



Superpolishing machine for mandrels at OAB

Constellation-X HXT flux sensitivity compared with other missions of past, present and future

Assumed parameters: 4 satellites, 4 modules/satellite, HPD = 20 arcsec, Ni/C coating

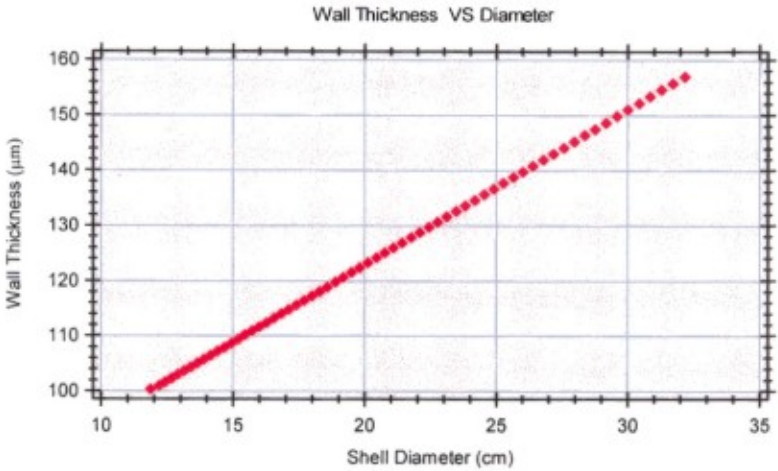
Integration Time = 10^5 s
Energy Band-Width: $\Delta E = 50\ \%\ E$
Level of Confidence: $3\ \sigma$
Background Assumed for Constellation X: 10^{-4} counts/cm^2/s/keV

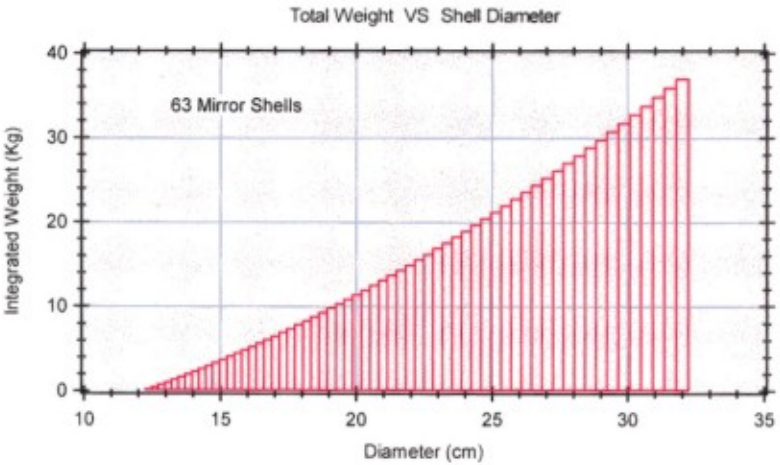


N.B.:
assumed background for HXT: 10^4 counts/cm^2/s/keV

4 modules/satellite configuration

Total Weight/Satellite = 197.6 Kg
(including structure, 30 % of mirr. weight)





REALIZATION METODS FOR ASTRONOMICAL HARD X-RAY MULTILAYER OPTICS

Two main philosophies are pursued:

A. the deposition of the multilayer coating onto segmented substrates (quarters of a cone) to be later on assembled to form double-cone optics;

It is the extension of the techniques used to realize the high-throughput Au coated soft-X telescopes ASCA, ASTRO-E and SODART.

B. the use of replication techniques by Ni electroforming for the realization of integral double-bounces shells with Wolter I ore double cone profile.

It is the up-grade of the method successfully used to manufacture the high-throughput & good-imaging Au coated soft-X telescopes SAX, JET-X and XMM .

This last approach can be achieved following further on 2 alternative ways:

I. the deposition of the multilayer film at the interior of a mirror support previously fabricated by replication via Ni electroforming,

II. the direct deposition of the multilayer film onto the mandrel surface and successive replication of the mirror by Ni electroforming.

Work in progress

- realization of a fully representative single-cone mirror shell (diameter = 30 *cm*, height = 15 *cm*, focal length = 10 *m*);
- realization of a double-cone fully representative mirror shell (diameter = 12 *cm*, total-height = 54 *cm*, focal length = 10 *m*);
- X-ray imaging tests on the produced optics;
- X-ray test with pencil beams at OAB (Bede Scient. difractometer) and at the BM5 beamline at the European Synchrotron Radiation Facility (ESRF, Grenoble, Fr).

HXT Configurations, Weight, Effective Areas and Flux sensitivity: *an evaluation for the Ni electroformed option*

Two baselines have been considered:

- **3** modules for each of the 4 satellites (total: 12 modules);
  $diam_{MAX}$ = 40 *cm* $diam_{MIN}$ = 12 *cm*
  total mirror height = 80 *cm*
  number of shells = 78 (*x module*)

- **4** modules for each of the 4 satellites (total: 16 modules);
  $diam_{MAX}$ = 33 *cm* $diam_{MIN}$ = 12 *cm*
  total mirror height = 80 *cm*
  number of shells = 63 (*x module*)

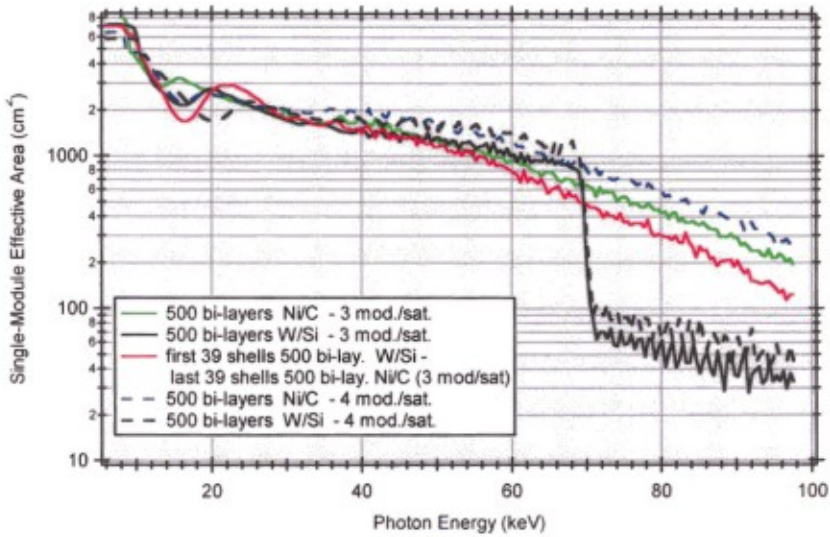
Further on two alternative mirror profiles have been supposed:

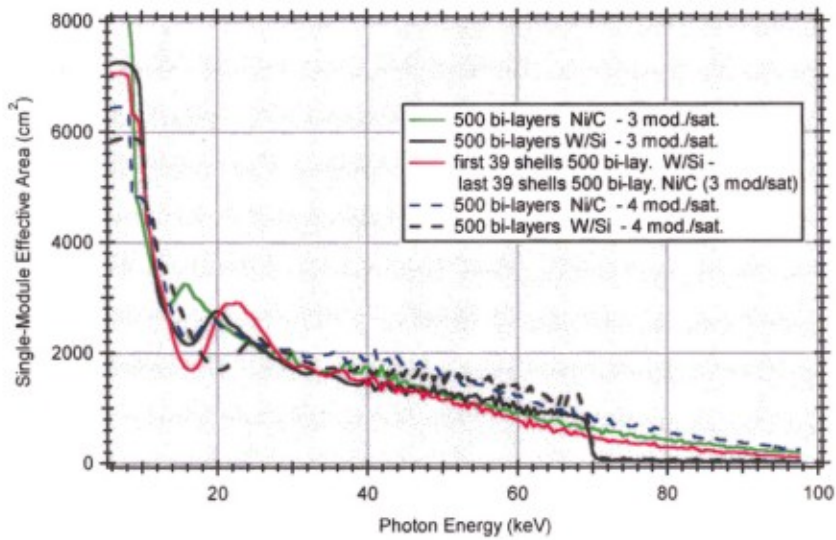
- double-cone: estimated HPD = 30 *arcsec;*
- Wolter I: estimated HPD = 20 *arcsec.*

Possible multilayer coatings:

- Ni/C, W/Si (or both).

Total on-axis effective area for Constellation-X HXT
(Ni electroformed shells assumed)

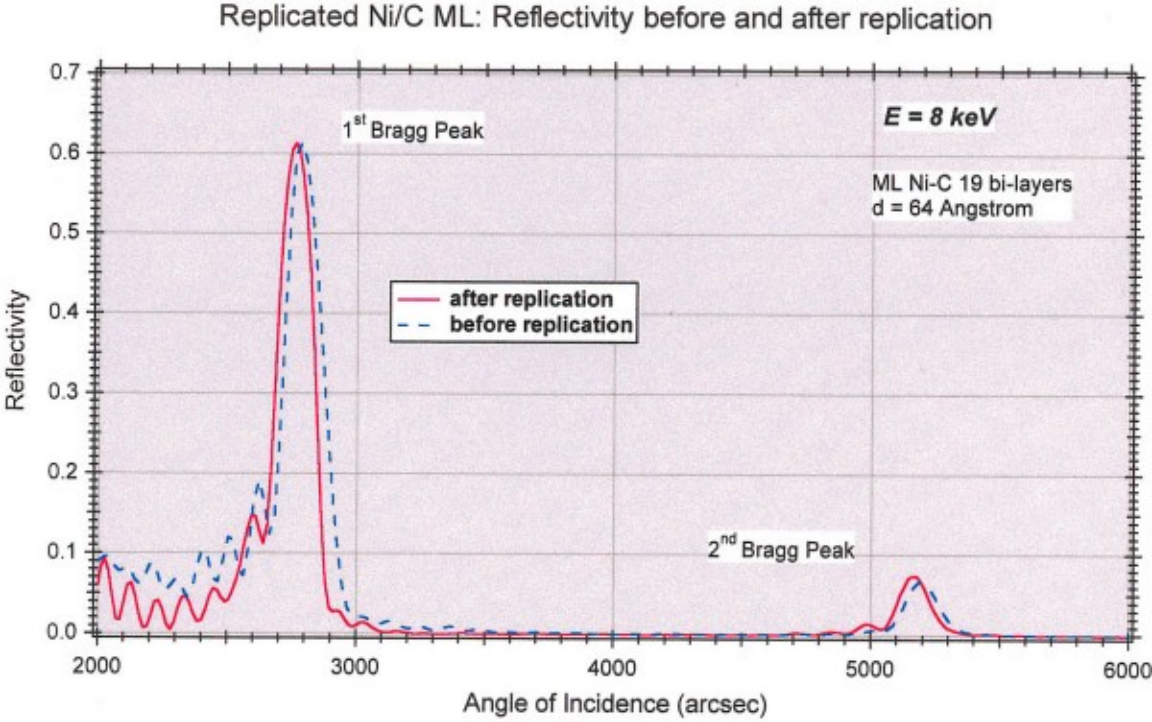


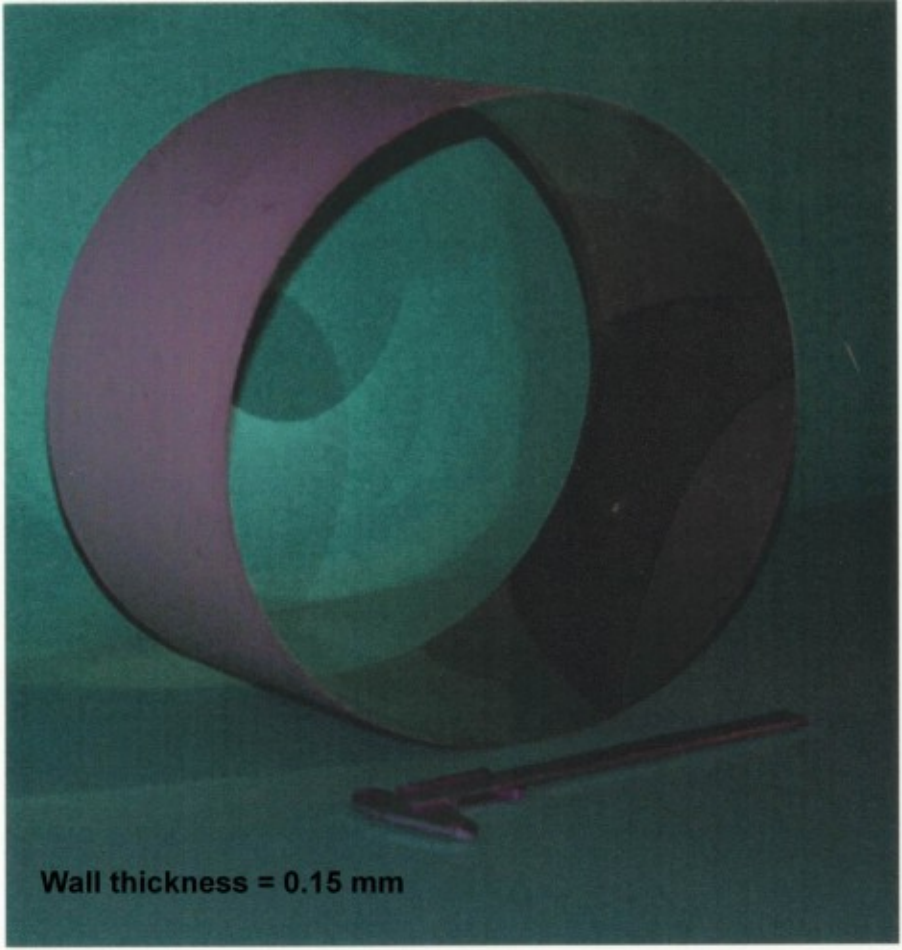


ADVANTAGES CONNECTED TO THE DIRECT REPLICATION OF MULTILAYER COATINGS BY Ni ELECTROFORMING METHOD

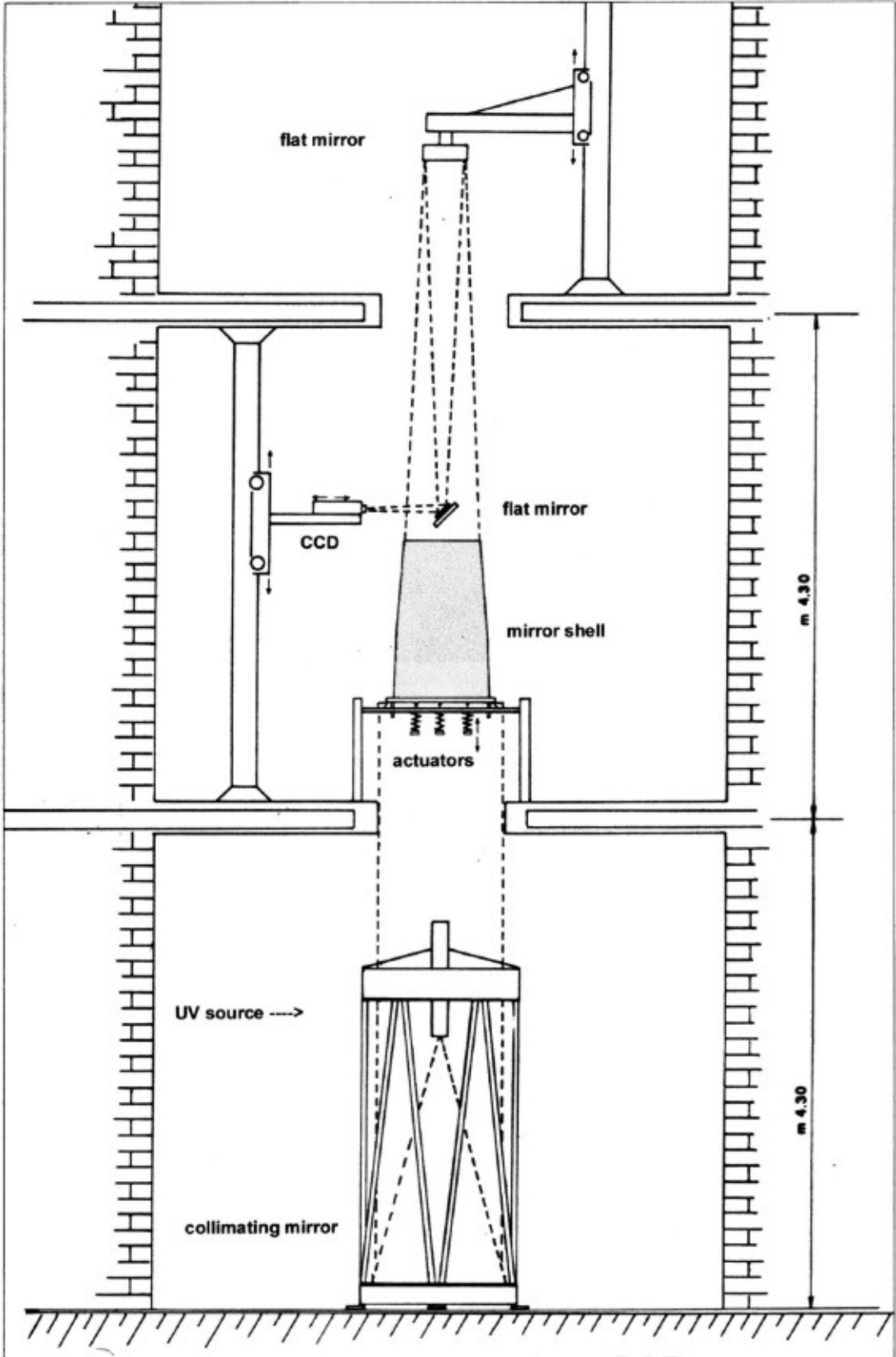
The direct deposition of the multilayer stack allows a number of advantages:

- no limits for the minimum mirror diameter to be realized (the sputtering source is not placed inside the mirror);
- use of the ion-beam sputtering technique for deposition (➔ very smooth films);
- no problems of heat on the substrate;
- the closed structure with cylindrical symmetry gives better mechanical performances (➔ better angular resolution);
- free choice of profiles for the optics (double-cones, Wolter I, polynomial, etc.);
- small number of fabrication steps involved in the process;
- heritage of well known technologies for replication by Nickel electroforming.

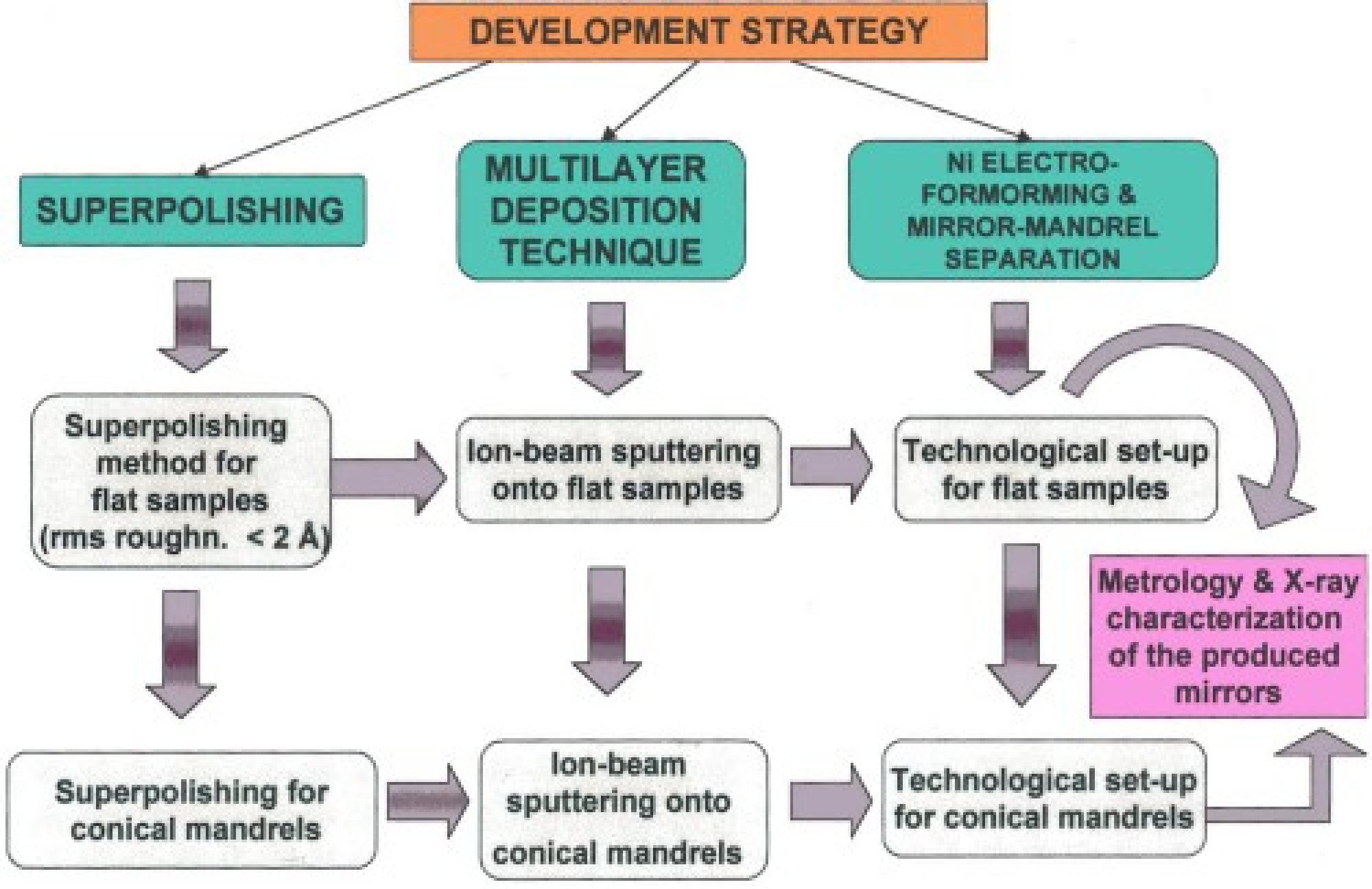

Replicated Ni/C ML: Reflectivity before and after replication
1st Bragg Peak
E = 8 keV
ML Ni-C 19 bi-layers
d = 64 Angstrom
after replication
before replication
2nd Bragg Peak
Reflectivity
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2000
3000
4000
5000
6000
Angle of Incidence (arcsec)



Ni electroformed single-cone shell - Coating Ni/C multilay
Ø 28 cm - Taper angle 0.2° - Mirror heigth 15 cm



Vertical optical bench at OAB


DEVELOPMENT STRATEGY
SUPERPOLISHING
MULTILAYER DEPOSITION TECHNIQUE
NI ELECTRO-FORMORMING & MIRROR-MANDREL SEPARATION
Superpolishing method for flat samples (rms roughn. < 2 Å)
Ion-beam sputtering onto flat samples
Technological set-up for flat samples
Metrology & X-ray characterization of the produced mirrors
Superpolishing for conical mandrels
Ion-beam sputtering onto conical mandrels
Technological set-up for conical mandrels

A FIRST Ni/C ML SAMPLE PRODUCED USING THE REPLICATION BY NICKEL ELECTRO--FORMING METHOD

A. Production of a Nickel superpolished substrate

An Aluminum flat disk (Ø 100 *mm*) coated with a thin layer of electroless Ni has been superpolished.

Atomic Force Microscope (AFM) roughness measurements:

Scan length (microns)	Roughness RMS (Å)
0.5	0.85
1.0	0.91
10.0	2.07
100.0	3.60

B. Deposition of the Ni/C multilayer

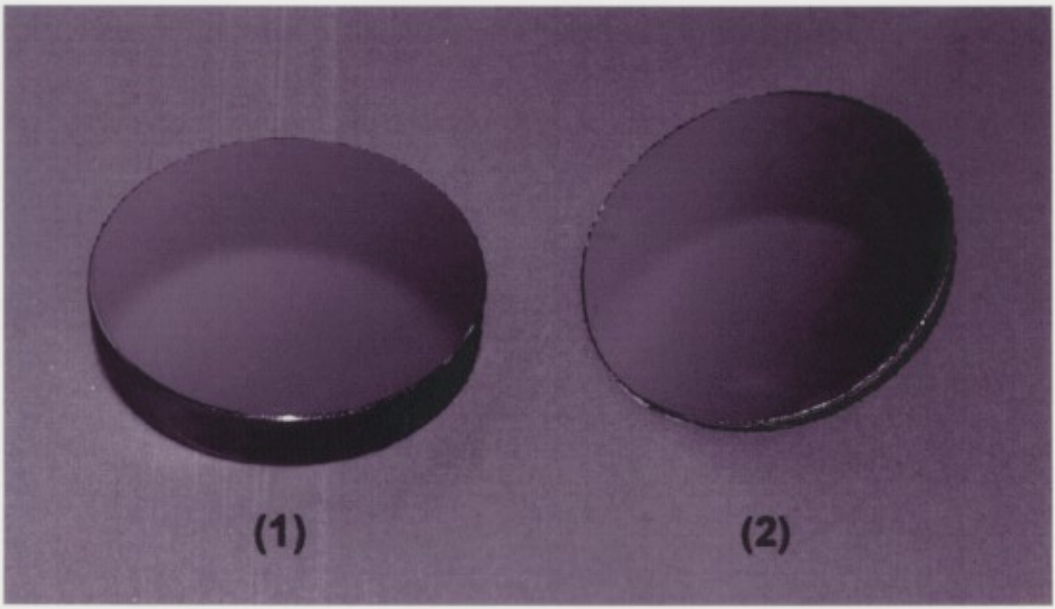
A Ni/C multilayer (19 bilayers, d-spacing = 6.4 nm, gamma = 0.73) has been grown on the nickel substrate via ion beam sputtering by CETEV- Carsoli (Rome).

Measurements with the AFM after the deposition have given the following results:

Scan length (microns)	Roughness RMS (Å)
0.5	0.85
1.0	1.89
10.0	3.64

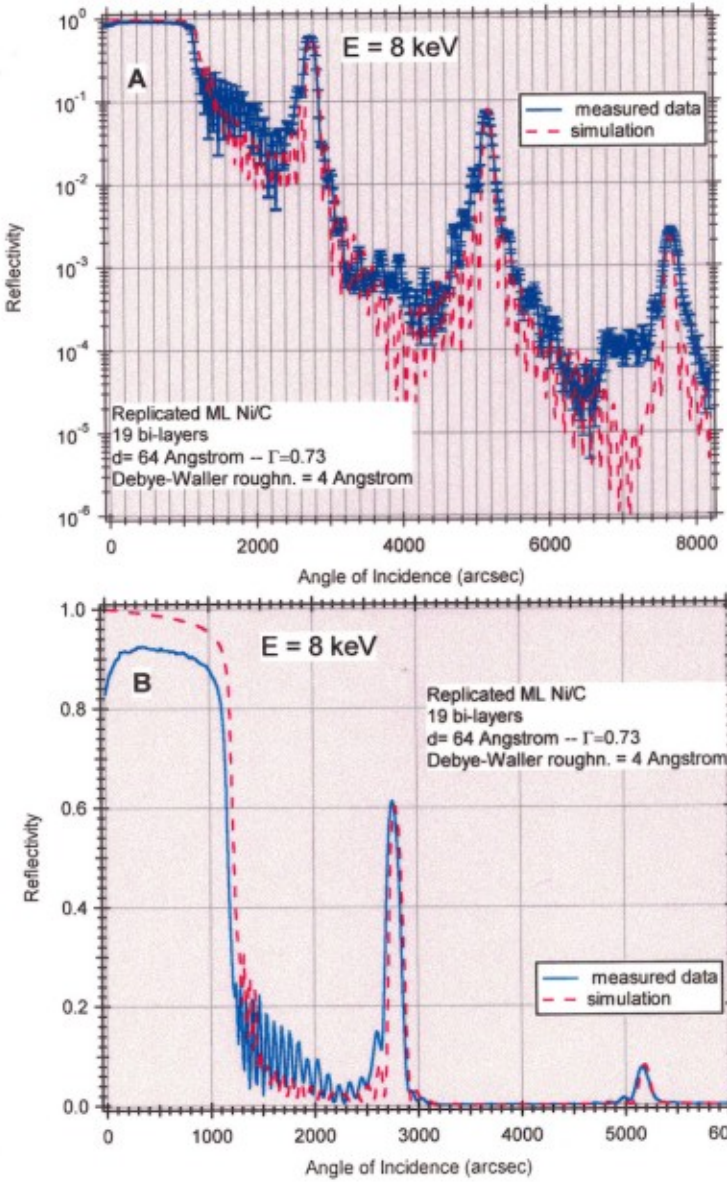
C. Replication of the ML film by Ni electroforming

The multilayer film has been afterwards replicated by nickel electroforming.



The x-ray reflectivity of the ML mirror has been measured and compared with the reflectivity profile of the ML before replication previously measured.

ML SAPLE AFTER REPLICATION



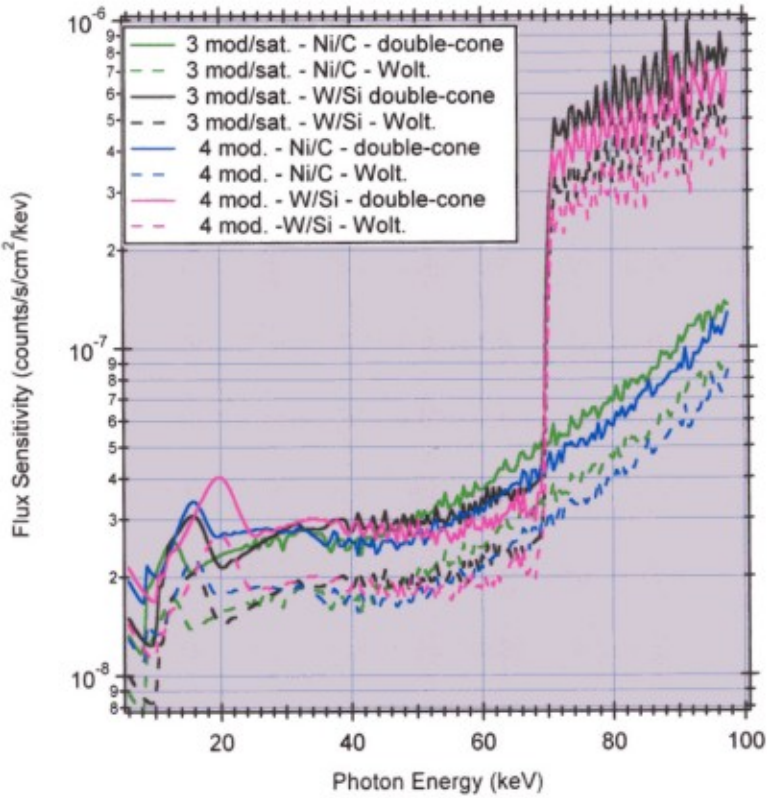
Part B:
Optics for the HXT (Hard X-ray Telescope)

- The technology under investigation at OAB for the *Constellation-X* HXT:
  multilayer replicated optics by Ni electroforming;
- Results obtained for flat and conical samples produced exploiting the direct replication of the multilayer mirror by Ni electroforming;
- Evaluation of weight, effective area and flux sensitvity for possible HXT configurations based on Ni electroformed shells;
- Work in progress and future activities.

ON-AXIS FLUX SENSITIVITY

$\Delta E = 50\ \%\ E$ Integration Time = 10^5 s

Confidence Level = 3 σ

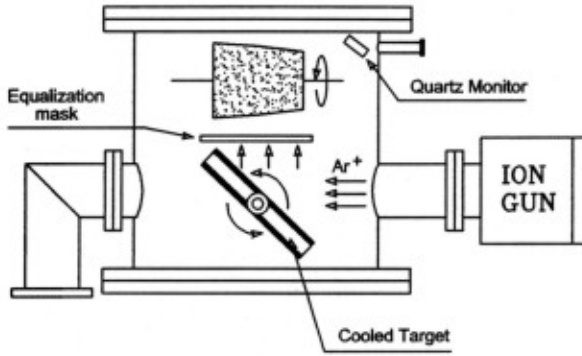


N.B.:

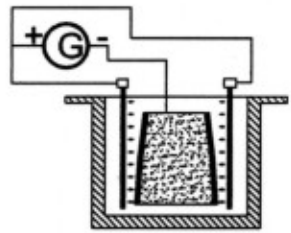
assumed background = 10^4 counts/cm^2/keV/s (only intrinsic)

Superpolished
Mandrel

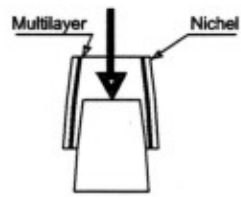
Multilayer
deposition



Electroforming



Mirror shell
Separation



Grazing incidence multilayer optics manufactured by Ion-Beam Sputtering deposition of the multilayer on the mandrel

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Diseg. Garegnani
Data 07 / Sett. / '98

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